Nasdaq Decodes: Tech Trends 2020

THE TECHNOLOGY TRENDS THAT ARE DRIVING THE WORLD OF MARKETS FORWARD

Nasdaq

Nasdaq

Nasdaq Decodes: Tech Trends 2020

THE TECHNOLOGY TRENDS THAT ARE DRIVING THE WORLD OF MARKETS FORWARD

Foreword

Our founders launched the world's first electronic market in 1971, and over the decades it became the benchmark for exchanges around the world. Since then, advancements in technology have enabled the capital markets to undergo a complete transformation and achieve greater operational efficiency and lower costs while providing exciting new products and a better experience for our clients.

Exchanges are a central hub where buyers and sellers come together. Price discovery is when the buyer and the seller agree on the value of an asset at any given moment, and both have an equal role. We see an opportunity to bring that dialog between buyers and sellers into the broader economy, and make it more inclusive through markets everywhere. The work we have done has created the foundation for new types of marketplaces to emerge. These companies are disrupting their industries by providing a platform and business model for price discovery and matching buyers with sellers of an array of financial and non-financial assets. Among them are shipping and logistics, advertising and reinsurance to name a few.

2020 is the fourth year that we have published a report on the technology trends that we think are having the most impact on our industry, and our outlook for the year ahead. Three key trends have led us to where we are today, and are reflected in our priorities:

First, the creation of data through machine-to-machine communication and the internet of things, and the ability to process data at scale and in real time, lies at the core of innovation. Machine learning and artificial intelligence tools are increasingly being used to analyze data and deliver actionable insights. Blockchain is expanding the universe of markets that can be digitized and providing collaboration and trust where it is lacking. Moreover, user interface tools and microservices are helping to leverage detailed information about user experience and customer behavior in selling channels.

Second, the ability to source and process valuable data is allowing businesses to go real time. Streaming technology that broke ground in the world of social media and entertainment is now being utilized in the capital markets. Moreover, robotic process automation is leading to more efficient use of resources and a consistent, predictable, reliable, scaled operational model.

Third, machine-to-machine communication is creating new data, and platforms and APIs are enabling it to be integrated. Serverless compute in the cloud is reducing capital costs and shifting the focus to customers' needs instead of setting up, configuring, patching and maintaining servers in the data center. Meanwhile, low code no code (LCNC) is simplifying the process of building and testing of mobile and web applications.

Given the opportunities presented by these trends, we are pleased to offer you our view on the current state of technology of the capital markets and beyond. At Nasdaq, we work with these technologies and developments every day. They energize us and keep us focused on our path forward into an exciting future.

Brad Peterson

Executive Vice President and Chief Technology & Information Officer

Lars Ottersgård

Executive Vice President and Head of Market Technology

Data creation and the ability to process data at scale and in real time lies at the core of innovation.

Over the last few decades, companies across all industries have been going digital, and nowadays people often use the catch phrase "digital transformation". However, digital transformation means different things to different people. For some it relates to marketing and communications—essentially instrumenting the customer interface and managing the customer's entire experience with a product or company in multiple channels. For others it is about reimagining ways to bring together people, data and processes to help engage clients, empower employees, optimize operations and transform products and services. Despite the overuse of the phrase, it captures an element of change that is worth noting.

An exciting subset of digital transformation is machine-to-machine (M2M) communication—machines exchanging data without human interfacing or interaction. Today, much of the economy is based on it. In industrial internet of things (IoT), it plays a key role in predictive maintenance, determining the condition of in-service equipment and estimating when maintenance should be performed. The technology is increasing supply chain efficiency by improving the accuracy of supply and demand forecasts. In healthcare, it is enabling doctors and patients to monitor diseases and systems. Moreover, financial market participants are not only using smart order routers and direct market access to obtain best execution, but also analyzing big data to make better investment decisions.

M2M communication produces data in "software-defined" ways, where the software has full control, no human intervention is needed, there are no hardware-specific dependencies, and functionality can be added or modified easily. It gives businesses the ability to ingest and compute large volumes of data in real time, so they can perform functions and scale quickly. In addition, they can be more predictive and bring automated decision-making closer to the edge.

Machine learning (ML), artificial intelligence (AI), edge computing and 5G networks

Innovation is reducing the reliance on batch processing, and lags are being eliminated by supporting technologies around the AI and M2M ecosystem. Over the past year, advancements in technologies such as edge computing, AI chips and fifth-generation wireless (5G) networks are taking this closer to reality. Edge computing reduces latency by processing data closer to the source of capture such as laptops, tablets and smartphones. AI chips are a new generation of microprocessors that are designed to process AI tasks faster, using less power. They could play a critical role in economic growth because they will feature in autonomous vehicles, smart homes and cities, robotics and other technologies. 5G is the latest iteration of cellular technology, engineered to greatly increase the speed and responsiveness of wireless networks, enabling autonomous vehicles to navigate in real time, for example.

Autonomous vehicle models use telemetry data for driver assist, but it is still necessary to have human drivers in vehicles. But ML is being run on years' worth of telemetry data that has been collected, and that data will get the automobile industry to the next phase, where vehicles are truly driverless. The way they make decisions will change, and the sensors that they use to make those decisions will change, too. Currently they use light detection ranging (LiDAR) systems, a remote sensing method that can be used to map structure. LiDAR acts as the eye of these vehicles and provides them a 360-degree view of the surroundings to help them to drive safely. A continuously rotating LiDAR system sends thousands of laser pulses every second. In the future, one can imagine the use of Controller Area Networks (CANs), a real-time system for vehicle intercommunication and coordination.

In the financial markets, trading systems have already been optimized down to microseconds, and soon they could run in nanoseconds. **At Nasdaq, we believe M2M communication, ML, AI and the supporting tools and technologies are important because they can help us to measure, monitor and understand what is happening at scale and high speed. We are using ML and AI to process vast data volumes created by machines and deliver valuable insights about tradeable assets. Externally, our clients have automated trading, but increasingly we expect them to track the data as they make decisions and evolve their systems to the next level.**

M2M communication provides opportunities to develop new marketplaces for financial and non-financial assets, and technologies such as blockchain can expand the universe of markets that can be digitized. Blockchain is an enabler for

collaboration among market participants as well as M2M communication, especially where trust and transparency are lacking. Smart contracts ensure that machines act according to certain rules when settling and managing assets. **The landscape is evolving around vertical integration across the ledger, smart contracts and business application layers on top, and now the cloud vendors are introducing blockchain-as-a-service solutions. Notably, it is interesting that large banks are building capabilities in the institutional trading and custody of crypto-assets.**

Meanwhile, user interface/user experience (UI/UX) tools are enabling markets and marketplaces to leverage detailed information about user experience and customer behavior in selling channels. Microservices and application programming interfaces (APIs) are becoming the norm for applications to communicate, which in turn is enabling M2M communication. UIs are typically tied to a specific application. But in the future, an aggregation layer enabled by APIs and UIs will allow generalized applications to communicate, thus providing a better client experience. We are moving this way with the Nasdaq Financial Framework, a platform that has multiple applications for trading, clearing and settlement and functions can be handled through one UI.

> "We are seeing **major transformations** in every industry, but especially in **financial services** due to **machine learning**, due to the **platform revolution**, and due to **crowd-based innovation**.... Each of those is changing the economy, driven at its core by digital technologies. But what's important to understand is it's not simply the technologies that are driving this. It's really the **invention of business models** and business processes, and those are much subtler and harder to understand, but ultimately **much more important**.[1]"
>
> —**Eric Brynjolfsson,** Co-Founder & Director at MIT Initiative on the Digital Economy, MIT Sloan School.

The ability to source and process valuable data is allowing businesses to go real time.

Edge computing and IoT are generating huge amounts of data, and markets and marketplaces need the capacity to store it and transport it from point of source to point of interest. MQ Telemetry Transport (MQTT) is an M2M/IoT connectivity protocol. This technology has been used in sensors communicating to a broker via satellite link, over occasional dial-up connections with healthcare providers, and in a range of home automation and small device scenarios. It is also ideal for mobile applications because of its small size, low power usage, minimized data packets and efficient distribution of information to one or many receivers.[2] However, MQTT has limitations that are being addressed by other technologies.

Apache Kafka

Originally developed by LinkedIn and now available as open source via Confluent, Apache Kafka is an enabling technology for handling large data volumes and doing business in real time. **Kafka is an open source streaming platform that can publish and subscribe to streams of records, similar to a message queue or enterprise messaging system.** It can store streams of records in a fault-tolerant, durable way, and it can also process streams of records as they occur. The technology is generally used for building real-time streaming data pipelines that reliably get data between systems or applications, as well as real-time streaming applications that transform or react to the streams of data.

The combination of a message queue and a publish-and-subscribe architecture has significant benefits. With a message queue, the message or data is transported between the sender and the receiver application, but the message queue is limited because only one consumer can pull off the messages. But with publish-and-subscribe, multiple consumers can have access to categories or subsets of messages filtered according to topics or content. Further, message delivery is guaranteed—a feature that is critical for markets and marketplaces.

Kafka's event-driven model optimizes the compute and network transport, so markets and marketplaces can gain the scale necessary to achieve business in real time. Edge compute instances and their datasets can be connected into a forum where the business can access them and extract actionable insights from them.

While Kafka is not new in the last year, markets and marketplaces have gained a better understanding of how it can be applied, which is driving wider adoption. They now realize that when combined with cloud technology, it provides the scale that previously was unobtainable.

For some time, the cloud vendors have been providing managed services. Among them are Amazon Kinesis, Google Cloud Pub/Sub and Google Cloud Dataflow as well as Azure Stream Analytics, but there are several others. Yet, many markets and marketplaces recognize the need for a multi-cloud strategy and the technology to support it. They are thinking more about how to run workloads in multiple clouds using Kafka. A Kafka operator for Kubernetes allows them to provision Kafka through a multi-cloud-agnostic stack. That way, they can take control of the workloads and run them wherever they choose, as well as scale out while avoiding vendor lock in.

Kafka has enabled the vision for event-driven microservices, which is important for digitalized businesses.

"The possibilities are immense. Everything happening in your business is an event. It's available instantly to all applications in the company that need to process it. You have the ability to query data and respond to it as it arrives versus when it is too late. And all this is possible by also simplifying your data architecture by deploying a single platform that replaces your mesh of different tools by relying on this central streaming platform.[3]"

—**Neha Narkhede,** CTO of Confluent

Over the last year, markets and marketplaces have come to accept both the multi-cloud and hybrid strategy. There is a growing acceptance of an expanded ecosystem where workloads and data are on premise, in one cloud or in multiple clouds. They need solutions that allow all those datasets and workloads to be connected. Let's say an exchange is advanced at cloud, but it still has some workloads that are on-premise. In order to provide actionable insights, it needs to bring that data alongside the datasets it has natively in the cloud or alongside external datasets. Kafka is the key enabling technology for that.

At Nasdaq, we see a wide range of use cases for Kafka and complementary technologies. One is to take huge volumes of on-premise trading data, and stream it in real-time through client portals. Kafka can bridge the on-premise source of the real-time, high-volume data to the cloud, providing a more cost efficient, scalable and responsive solution for clients to manage their order flow. Kafka can also be used in streaming analytics for risk management, surveillance and compliance workloads.

Robotic process automation

Robotic process automation (RPA), also known as chatbots, is enabling business in real time as well. RPA systems develop an action list by watching the user perform a task in the application's graphical user interface (GUI), and then perform the automation by repeating those tasks directly in the GUI. RPA helps financial firms achieve better results from the datasets collected in real time.

In financial services, many tasks are performed by humans, but in most cases they do not require special handling or complex problem solving. There is an opportunity to automate those processes, therefore allowing people to focus on exceptions. RPA can be applied to market operations functions that need to be done at scale and automated, including surveillance and compliance case management.

Automation results in a better outcome for the markets as a whole, and allows markets and marketplaces to use resources more efficiently. It also helps them to achieve a consistent, predictable, reliable, scaled operational model.

RPA has gained wider acceptance in the financial markets over the past year. Some markets and marketplaces are leveraging tools such as ServiceNow to deliver workflows, and then fitting AI-based RPA from vendors such as Kryon on top. There are use cases in the customer facing space, especially as markets and marketplaces scale out and implement software-as-a-service (SaaS) models.

The improved efficiency and consistency RPA brings leads to a better customer experience. It could transform the way markets and marketplaces work, and bring customers closer to the core of their value proposition. The technology enables several domains to be handled without requiring layers of organization between the customer and the product teams. In addition, it helps to tackle some of the fixed overhead and reduce costs while maintaining full compliance and efficiency. On the other hand, markets and marketplaces

need to demonstrate that RPA supports and is consistent with the regulatory environment, and they must be able to explain to regulators why a process, decision or steps were taken.

Nasdaq is leveraging RPA in one of its commercial businesses to compile reports, regulatory filings and news releases using natural language processing, and then summarize them in a human readable format. RPA is also central to the scale-out of our SaaS product strategy. It will allow us to interact with more clients and take advantage of the product model that we have been building over the past few years. From our perspective, it is key to our growth and our customers' success.

Platforms and APIs are enabling M2M-generated data to be integrated.

Platformification is having an impact on financial services and other industries. **Products are being bundled together and monitored to see how clients interact with them, and that information is used to deliver a differentiated client experience. Platforms are also enabling markets and marketplaces to become fully digitized and connect all the parts of their business.**

APIs already existed in the world of markets, and ITCH, OUCH and FIX are examples of this; however, these are bespoke and specific. But APIs are an important piece of platform and integration because well-structured APIs allow markets and marketplaces to innovate quickly. Essentially, APIs can be combined in unique ways, and integrated into solutions quickly.

To illustrate, Twilio virtualizes the world's communications infrastructure through simple APIs that any developer can use. Lyft has used Twilio's APIs to create one of the most successful ride sharing marketplaces on the planet.

Goldman Sachs' use of APIs illustrate how this technology can yield improvements in the financial markets. The company has three main APIs: GSQuant, PlotTool Pro and Marquee API Developer. Marquee allows clients to directly access the bank's pricing and analytics platform for anything from back-testing trade ideas to index creation and portfolio rebalancing. GSQuant provides a toolkit for quantitative finance underpinned by Goldman's risk platform. PlotTool Pro provides access to Goldman's historic derivatives trading data and models of derivatives markets. At a recent conference, the bank's CEO told attendees that its new Marquee products, which make its SecDB database directly accessible to clients, will be available as APIs in the cloud.

API economy, the exposure of a firm's digital services and assets through APIs in a controlled way, is tightly interlinked with the cloud, thus establishing a foundation for innovation and scalable growth. Vendors such as Kong and RapidAPI make connecting APIs and microservices across today's hybrid, multi-cloud environments easier and faster.

Serverless compute

Serverless compute is enabling this trend. In on-premise environments, financial firms must purchase (capitalize), deploy, provision and maintain hardware, including servers and storage arrays, to run an application and to store data. In a traditional cloud environment, there is still a certain amount of provisioning and maintenance work required for infrastructure. This is considered "undifferentiated heavy lifting" in that companies are dedicating resources to these activities instead of focusing on developing the features that their customers want. **With serverless compute, applications (or parts of applications) are triggered to run on demand on hardware that is dynamically provisioned by the cloud provider. The cloud provider takes care of the scale and security, making the infrastructure essentially invisible. Nowadays, the cloud providers offer different types of serverless compute environments that can handle all but the most obscure patterns.**

Serverless compute is connected to the idea of using event-driven architectures to drive more efficient usage. In traditional cloud models, servers and storage are provisioned in "whole units". For example, a server with a certain number of CPU cores, memory and storage might be pre-provisioned to run an application. Usually the server is sized to handle high capacity events (e.g. high customer usage), but those resources go unused during other times when the application may be experiencing low usage volume. Infrastructure use is adjusted dynamically through load balancing and other mechanisms, but that still requires starting up whole servers and running entire operating systems to account for the increased load. Serverless compute moves the hardware provisioning problem to the cloud provider completely and allows more granular control of resource use according to demand.

Markets and marketplaces can put together a more flexible and adaptive architecture and just pay for what they use. This allows for a more seamless and higher-quality customer experience, and it lowers costs and increases efficiency for operators. Self-scaling services within the cloud, such as AWS's Lambda, is an example of a serverless service.

The Kubernetes open-source platform for automating deployment, scaling and managing containerized applications in the cloud lowers costs and reduces cloud vendor lock-in. Containers are wrapped into a higher-level structure called a pod. Any containers in the same pod will share the same resources and local network, and pods can scale up or down on hardware. Furthermore, Kubernetes-native serverless frameworks are available to enable serverless workloads within Kubernetes.

Some cloud providers are offering serverless database services. An example is Amazon Aurora Serverless, which claims to start up, shut down and scale capacity based on application needs. Other cloud providers are moving in this direction as well. More database services will be offered over time.

Nasdaq has embraced a vision for running serverless across many workloads. One example is exchange data processing, which has traditionally been batch-oriented, where the data is uploaded into the cloud at the end of the day for processing. We can now do real-time data streaming into the cloud and leverage the serverless technologies that the cloud offers to address variable volume/capacity events that occur throughout a normal trading day.

The main challenge is the change in process and culture that comes along with introducing new technology. Markets and marketplaces have to get to a point where they have enough detailed information and analysis of how the serverless technologies work, especially with regard to compliance, information security and data protection.

Low code no code

Low code no code (LCNC) is another enabling technology. It allows users to build and test applications such as mobile or web apps by dragging and dropping application components connecting them together. They do not have to know anything about traditional programming languages or the development work that goes into building the platform's configurable components.

This approach enables APIs to become self-discoverable. Instead of putting a static document on a web site explaining how to program to a particular API, the actual schema inside the APIs become self-discoverable to customers that want to retrieve that information. The logic for how to discover and retrieve the data is programmed into one process.

Nasdaq is doing real-time processing on market data and on its market operations platform in the cloud, and it has settled on a data schema that is self-describing. In consuming applications, it is not necessary to program in the information about how to parse and understand that information. The real-time data feed provides the information to the consuming application about what the schema is and how to consume it.

We are moving away from delivering historical market data in a downloadable file that consumers have to figure out how to read. **The new LCNC approach involves API access to the data that is also self-discoverable. Exposure through APIs and LCNC solutions increase the value of our platforms, solutions and services. Our goal is to enable faster ideation and more frictionless interaction, leading to a network effect. Importantly, we can deepen the relationship with our clients as they build more on top of our platforms, solutions and services.**

Nasdaq is delivering the API platform model with the Nasdaq Financial Framework, which incorporates serverless architectures and evolving the way markets function. In 2020, we are planning to create a data platform model for many products. To this end, clients will have access to a much more modern platform and API ecosystem, allowing them to gain understanding of what is happening in their business and provide more value to their own customers.

Conclusion

Markets and marketplaces are leveraging innovative and potentially disruptive technologies to increase efficiency, reduce costs, enhance security, improve the customer experience, generate revenue and facilitate regulatory compliance. Many of them are already building the cloud, M2M, ML, AI and blockchain technologies into their strategy. They are actively participating in industry working groups to figure out how they can make the best use of technologies such as Kafka, RPA, serverless compute and LCNC, and ensure their implementations comply with regulations.

Further, they are looking toward other industries, such as the automotive sector, for fresh ideas about how to leverage technology to achieve objectives. They are following developments in emerging technologies, including edge computing, AI chips and 5G networks with a view to implementing them when and if it makes sense. It is fascinating to watch these technologies converge into the solution for the future.

In 2020, we are undergoing our own transformation both as a marketplace and as a technology provider. As we provision our technologies increasingly towards other industries, and we see the lines blurring more between capital markets and markets everywhere, we are working to transform into a true platform company delivering business value through robust APIs and services. We strive to be the enabler of innovation in our industry, but also beyond. 2020 will be a year of execution: where we will implement emerging technologies to solve real business problems, where we will drive adoption of cloud technology and we will solve legacy infrastructure challenges for our clients.

We are excited about the future of markets and look forward to partnering with market participants, issuers, regulators and other technology companies as well as new marketplaces outside of capital markets. Together we will strive to create a stronger, more efficient and transparent marketplace economy that is ready to take on the next decade, and decades to come.

[1] See Erik Brynjolfsson on the Triple Data Revolution, https://www.youtube.com/watch?v=NoXZNvrX7dY.

[2] See http://mqtt.org/.

[3] See “Apache Kafka Streaming Platform Explained,” https://www.youtube.com/watch?v=A9KQufewd-s

[4] See https://news.efinancialcareers.com/us-en/3002807/goldman-sachs-apis